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# Stock Market Linkages in Emerging Asia-Pacific Markets

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## Abstract

This study examines the stock market integration among major stock markets of emerging Asia-Pacific economies, viz. India, Malaysia, Hong Kong, Singapore, South Korea, Taiwan, Japan, China and Indonesia. Johansen and Juselius (1990) multivariate cointegration test, Granger causality/Block exogeneity Wald test based on VECM approach and Variance Decomposition Analysis was employed to investigate the dynamic linkages between markets. Cointegration test confirmed a well defined long-run equilibrium relationship among the major stock markets, implying that there exists a common force, such as arbitrage activity, which brings these stock markets together in the long run. The results of Granger causality/Block exogeneity Wald test based on VECM and Variance Decomposition Analysis revealed the stock market interdependencies and dynamic interactions among the selected emerging Asia-Pacific economies. This result implies that investors can gain feasible benefits from international portfolio diversification in the short-run. On the whole, the study results suggest that although long-term diversification benefits from exposure to these markets might be limited, short-run benefits might exist due to substantial transitory fluctuations.

**Keywords:** Stock Market Integration, Cointegration, Vector Error Correction Model, Variance Decomposition Analysis

**JEL Classification:** C32, F36, G15

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## 1. Introduction

Over the last three decades, degree of integration of stock markets around the globe increased significantly as a result of liberalisation of markets, rapid technological progress and financial innovations, which has created new investment and financing opportunities for business and investors around the world. Stulz (1981) defined stock markets as being integrated 'if assets with perfectly correlated returns have the same price, regardless of the location in which they trade'. A fully integrated market is defined as a situation where investors earn the same risk-adjusted expected return on similar financial instruments in different national markets (Jorion and Schwartz, 1986) which means arbitrage profit will not be achieved. Accordingly, the stock market integration hypothesis stated that there were potential gains from international portfolio diversification if returns from investment in different national stock markets are not perfectly correlated and the correlation structure is stable. This implies that low levels of co-movement of stock prices offer investors the benefit of diversifying their holdings across the global stock markets. That is, investors who allocate some of their portfolio to share from other countries can increase the portfolio's expected return with no increase in risk. This benefit of international diversification has led many investors to allocate some of their wealth to foreign markets and shares of foreign firms. Thus, with the growing global economy, understanding international stock market correlations has become a vital instrument for investors wishing to diversify their portfolios on a global basis. For institutional and individual investors to have effective international portfolio diversification, it is important to determine the countries whose stock prices move together, i.e. to investigate the correlation structure and interdependencies among international share price indexes to a considerable extent. Unfortunately, previous empirical studies of the interrelationship of the major stock price indexes have not provided reliable results. Given the divergent conclusions of the researches in this area, further insights should be obtainable through an investigation of emerging markets. This study examine the stock market linkages between eleven emerging economies, viz. India, Malaysia, Hong Kong, Singapore, South Korea, Taiwan, Japan, China, Indonesia, United States and United Kingdom. The United States and United Kingdom stock markets are taken into account in

the present study for its significant role as the market leaders. Further, it is useful to know whether the major stock markets of United States and United Kingdom influences the emerging Asia Pacific markets. We employed correlation analysis, Johansen multivariate cointegration test and vector error correction model to investigate dependencies in stock returns of the emerging economies. The correlation analysis is performed to ascertain the degree of association among the emerging stock markets. Cointegration test, to verify whether long-term relationship exists, and the vector error correction model to examine whether returns of one market influences another.

The remainder of this paper is organized as follows: section 2 provides the review the literature on stock market linkages. Section 3 presents methodology of the study. The empirical results and discussion are provided in section 4 and section 5 presents concluding remarks.

## **2. Literature Review**

The earlier literature pertaining to stock market integration provides strong evidence of interlinkages among the stock markets around the globe, as a result of global economic integration. The interest in the interdependencies of global stock markets strengthened after the global market crash of October 1987. Taylor and Tonks (1989) examined the market integration of the US, Germany, the Netherlands and Japan for the two subperiods: April 1973-September 1979, and October 1979- June 1986. The result showed no cointegration between the stock price returns of these countries in the former period, and there was cointegration between the stock price returns of the UK with the stock price returns of the US, Germany, the Netherlands and Japan in the latter period. Jeon and Von-Furstenberg (1990) showed that the degree of international comovement in stock price indexes has increased significantly since the 1987 crash. On the other hand, Koop (1994) used Bayesian methods and concluded that there are no common trends in stock prices across countries after the crash. Cheung and Ng (1992) investigated the dynamic properties of stock returns in Tokyo and New York, using GARCH model for the period January 1985-December

1989. They found that in the pre-crash period, Tokyo stock price movements can be partially explained by the New York Stock Exchange, but the former has very little impact on the latter. Lee and Kim (1994) provided evidence for a significant increase in the comovement of the stock price indexes after the crash. The national stock markets became more interrelated and stronger when the US stock market was more volatile. Choudhury (1994) examined the relationship among the Asian Newly Industrialized Economies (NIEs), Japan and the US. He found that the US led the NIEs and that there were significant linkages between the markets. Arshanapalli et al. (1995) examined the possible links and dynamic interactions between the US and six major Asian stock markets before and after October 1987. The empirical results proved presence of a long-run equilibrium relationship between the US and Asian stock market movements during the post-October 1987 period. The cointegration results, based on the Asian equity markets alone, supported the possibility of increased regional capital market integration among the six Asian stock exchanges during the post-crash period. However, their error correction analysis, at the regional level, failed to support the presence of a strong cointegrating relationship among the Asian markets. Lastly, they concluded that the Asian equity markets were less integrated with Japanese equity market than they were with the US market. Corhay et al. (1995) investigated the stock market linkages of Australia, Japan, Hong Kong, New Zealand and Singapore over the period February 1972 to February 1992 and found no evidence of a single stochastic trend for these countries.

Chaudhuri (1997) investigated the long-run relationship between stock indexes of six Latin American markets and the US over the period 1985 to 1993 and he found the evidence of a stochastic trend in all indexes. The cointegration tests showed the presence of a long-run relationship between the six Latin American indexes (with and without the US return) and the error correction results proved the significant causality among the stated indexes. Francis and Leachman (1998) revealed that the US stock market influences other markets around the world. Janakiraman and Lamba (1998) examined the linkages between the stock markets in the Pacific-Basin region and showed that the US market influences all markets, except Indonesia. They found none of these markets exert a significant influence

on the US market. Liu et al. (1998) examined the interrelationship among the emerging and developed stock markets of Thailand, Taiwan, Japan, Singapore, Hong Kong and the US. They found that after the October 1987 crisis there was an increase in the general stock market interdependence among the emerging and developed stock markets and they also found interdependencies within the Asian Pacific regional markets.

With the emergence of Asian capital markets, studies have been done in the 1990s and thereafter focused the co-movements between Asian markets and the stock markets in developed countries. Masih and Masih (1999) studied the long- and short-term dynamic linkages among international and Asian emerging stock markets, and concluded that the US stock market was leader at the global level for short as well as long-term, and there was a significant relationship between the OECD and the Asian emerging markets. Agarwal (2000), with a correlation coefficient of 0.01 between India and developed markets, concluded that there is a lot of scope for the Indian stock market to integrate with the world market. Mishra (2002) investigated the international integration of India's domestic financial market with the US stock market. By applying the Ordinary Least Squares (OLS) method and cointegration technique, he found a positive correlation between NASDAQ and BSE. He concluded that BSE was influenced by the movements of NASDAQ. But there is no cointegrating vector between BSE and NASDAQ indexes, which shows that there is no long-run relationship between these two stock exchanges. Besides, the study of Kumar and Mukhopadhyay (2002) examined the short-run dynamic linkages between NSE Nifty and NASDAQ Composite during the period 1999-2001. The study supported a unidirectional Granger causality running from the US stock market to Indian stock market. Nath and Verma (2003) studied the transmission of market movements among the three major stock markets in the Asian region, viz., India, Singapore and Taiwan. The results proved that there was no long-term interrelationship and thus, international investors could achieve long-term gains by investing in the stock markets because of the independencies of the stock markets. By using the BSE-200 index, Wong et al. (2005) found that the Indian stock market is integrated with the matured markets of the world. Moreover, Hoque (2007) found the evidence that stock prices of Bangladesh, the US, Japan and India share a common

stochastic trend. Menon et al. (2009) examined whether the stock markets in the Indian subcontinent have any link with the major stock markets in China, Singapore, America, and Hong Kong. They found that the Indian markets are cointegrated to some of the markets around the world.

Bastos and Caiado (2010) found the evidences of integration and interdependence between the stock market returns of forty-six developed and emerging countries for the period 1995-2009. Similarly, Park (2010) found strong co-movement between Asian markets. Among those, the countries with more developed financial systems (i.e., Japan, Singapore, and Hong Kong in Asia) exhibited stronger linkages to the rest of the Asian markets. Using the time-series data ranging from 2, June 2005 to 2, April 2008, Arouri and Nguyen (2010) established no significant association between stock exchange of Gulf countries and the world stock markets. Subhani et al. (2011) identified the linkage of stock prices of Karachi Stock Exchange with the stock prices of Nepal and Bombay stock exchanges except Dhaka stock exchange. Samitas et al (2011) supported the existence of long-term relationship among Balkan stock markets and developed markets (US, UK, Germany). Besides, Sakthivel and Kamaiah (2012) attempted to investigate the dynamic inter-linkages among the Asian, European and US stock markets for the period January 1998 to June 2010. They showed that the US and some of the European and Asian Stock markets lead the Indian stock market. Horvath and Petrovski (2012) examined the international stock market comovements between Western Europe vis-à-vis Central (the Czech Republic, Hungary and Poland) and South Eastern Europe (Croatia, Macedonia and Serbia) and found that the degree of comovements is much higher for Central Europe and the correlation of South Eastern European stock markets with developed markets is essentially zero. Tripathi and Sethi (2012) examined the short run and long run inter-linkages of the Indian stock market with those of advanced emerging markets viz. Brazil, Hungary, Taiwan, Mexico, Poland and South Africa over the period ranging from 1, January 1992 to 31, December 2009. They showed that the short run and long run inter linkages of the Indian stock market with other markets has increased over the study period. Unidirectional causality is found in most cases.

The earlier studies pertaining to market integration and causality between world stock markets are well established, but provided the assorted results. Testing for cointegration among stock markets is a test of the level of arbitrage activity in the long run. If markets are not cointegrated, this implies that there is no arbitrage activity to bring the market together in the long run and, hence, the investors can potentially obtain long-run gains through portfolio diversification. In view of the various policy innovations in the emerging capital markets during the globalization era, it is highly desirable to test the stock market interdependencies among the emerging economies. Essentially, the degree of interdependencies of stock markets has major implications on potential benefits of portfolio diversification and on financial stability of the country. The current study attempts to examine the dynamic interdependence among major stock markets of emerging Asia-Pacific economies.

### 3. Methodology

#### 3.1 Cointegration approach

Johansen and Juselius (1990) multivariate cointegration approach and Vector Error Correction Model (VECM) have been employed to investigate the dynamic linkages among selected emerging Asia-Pacific stock markets. Before doing cointegration analysis, it is necessary to test the stationarity of the series. The Augmented Dickey-Fuller (1979) test was employed to infer the stationarity of the series. If the series are non-stationary in levels and stationary in differences, then there is a chance of cointegration relationship between them which reveals the long-run relationship between the series. Johansen's cointegration test has been employed to investigate the long-run relationship between the variables. Besides, the causal nexus between selected emerging stock markets was investigated by estimating the following Vector Error Correction Model (VECM) (Johansen, 1988 and Johansen and Juselius, 1990):

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \dots + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-1} + \varepsilon_t \quad (1)$$



where  $\Delta Y_t$  is  $(n \times 1)$  vector of stock market price changes in period  $t$ ,  $\mu$  is  $(n \times 1)$  vector of constant terms,  $\Gamma_i$  ( $i = 1, \dots, k-1$ ) represents the  $(n \times n)$  coefficient matrix of short-run dynamics,  $\Pi$  is the  $n \times n$  long-term impact matrix, and  $\varepsilon_{1t}$  is  $(n \times 1)$  vector of error term and it is independent from all explanatory variables. When cointegration is present, we can decompose the long-term response matrix into  $A = \alpha\beta'$ , where  $\alpha$  and  $\beta$  are  $n \times r$  matrices. In other words, the expression  $\beta' Y_{t-1}$  defines the stationary linear combinations (cointegration relations) of the  $I(1)$  vector  $Y_t$ , while the matrix  $\alpha$  of the error correction terms describe how the system variables adjust to the equilibrium error from the previous period,  $\beta' Y_{t-1}$ .

The Johansen's cointegration proposed two test statistics through VAR model that are used to identify the number of cointegrating vectors, namely the trace test statistic and the maximum eigen-value test statistic. These test statistics can be constructed as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \quad (2)$$

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (3)$$

where  $\hat{\lambda}_i$  are the eigen values obtained from the estimate of the  $A_k$  matrix and  $T$  is the number of usable observations. The  $\lambda_{trace}$  tests the null that there are at most  $r$  cointegrating vectors, against the alternative that the number of cointegrating vectors is greater than  $r$  and the  $\lambda_{max}$  tests the null that the number of cointegrating vectors is  $r$ , against the alternative of  $r + 1$ . Critical values for the  $\lambda_{trace}$  and  $\lambda_{max}$  statistics are provided by MacKinnon-Haug-Michelis (1999).

### 3.2 VEC Granger Causality

The Granger Representation Theorem (Engle and Granger, 1987) states that if a set of variables is cointegrated, then there exists a valid error correction representation of the data, in which the short-term dynamics of the variables in this system are influenced by the deviation from long-term equilibrium. In a VECM, short-term causal effects are indicated by changes in other differenced explanatory variables (i.e., the lagged dynamic terms in equation (1)). The long-term relationship is implied by the level of disequilibrium in the cointegration

relationship, i.e., the lagged error correction term (ECT). Thus, in the cointegration model, the proposition of 'Y<sub>k</sub> not Granger causing Y<sub>l</sub>' in the long-term is equivalent to  $\alpha_{kl} = 0$ . Y<sub>l</sub> is said to be weakly exogenous for parameter  $\beta$ , i.e., Y<sub>l</sub> does not react to equilibrium errors. Besides, the proposition 'Y<sub>k</sub> do not Granger-cause Y<sub>l</sub>' in the short term is equivalent to  $\Gamma_{kl}(L) = 0$ , where L is the lag-operator. Hence, the Vector Error Correction model is useful for detecting short- and long-term Granger causality tests (Granger, 1969). The VEC Model corresponds to equation (1) can be formulated as follows:

$$\Delta Y_{1t} = \mu_1 + \gamma_1 Z_{t-1} + \sum_{i=1}^{p-1} \theta_{1i} \Delta Y_{1t-i} + \sum_{i=1}^{p-1} \delta_{1i} \Delta Y_{2t-i} + \varepsilon_{1t} \quad (4)$$

$$\Delta Y_{2t} = \mu_2 + \gamma_2 Z_{t-1} + \sum_{i=1}^{p-1} \delta_{2i} \Delta Y_{2t-i} + \sum_{i=1}^{p-1} \theta_{2i} \Delta Y_{1t-i} + \varepsilon_{2t} \quad (5)$$

where  $Z_{t-1}$  is the error correction term derived from the cointegrating vector.  $\theta$  and  $\delta$  are the short-run parameters to be estimated,  $p$  is the lag length, and  $\varepsilon_t$  are assumed to be stationary random processes with a mean of zero and constant variance.

For each equation in the VEC Model, we employ short-term Granger causality to test whether endogenous variables can be treated as exogenous by the joint significance of the coefficients of each of the other lagged endogenous variables in that equation. The short-term significance of sum of the each lagged explanatory variables ( $\theta$ 's and  $\delta$ 's) can be exposed either through joint F or Wald  $\chi^2$  test. Besides, the long-term causality is implied by the significance of the t –tests of the lagged error correction term. However, the non-significance of both the t-statistics and joint F or Wald  $\chi^2$  tests in the Vector Error Correction Model indicates econometric exogeneity of the dependent variable.

### 3.3 Variance Decomposition Analysis

Finally, the study employed variance decomposition analysis to assess to what extent shocks to certain markets are explained by other markets in the system. Meaning, it tends to show the percentage of forecast error variance for each of the index selected that may attribute to its own shocks and to fluctuations in other indexes. Information from this analysis should provide some further evidence on the patterns of linkages amongst stock

markets, as well as contribute to enhancing insights upon how markets react to system-wide shocks and see how these responses propagate over time. This forecast error can be accounted for by its own innovations and the innovations of other variables in the system. In a statistical sense, if a variable explains most of its own shock, then it does not allow variances of other variables to contribute to it being explained and is therefore said to be relatively exogenous.

The data used in this study consists of daily stock indexes of the major stock exchange in the United States, United Kingdom and emerging Asia-Pacific economies, viz. India, Japan, Malaysia, South Korea, Thailand, Indonesia, Taiwan, Singapore and Hong Kong. The details of the stock exchanges and indices considered for the study are shown in Table 1. All indexes are expressed in terms of local currencies and are obtained from Bloomberg database. The sample period for the study covers from January 4, 2000 through January 31, 2013. Daily returns are identified as the first difference in the natural logarithm of the closing index value for the two consecutive trading days for the eleven major indices. We employed daily data rather than lower frequency data such as weekly and monthly returns because longer horizon returns can obscure transient responses to innovations which may last for few days only (Brailsford 1996, Elyasiani et al. 1998, and Andersen et al. 2002).

**Table 1: List of Emerging Stock Markets and its Stock Indexes**

<b>Country</b>	<b>Stock Exchange</b>	<b>Index</b>
India	National Stock Exchange	NIFTY
Malaysia	Kuala Lumpur Stock Exchange	KLSE
Hong Kong	Hong Kong Stock Exchange	HSI
Singapore	Strait Times Index	STI
South Korea	Korea Composite Stock Price Index	KOSPI
Taiwan	Taiwan Stock Exchange	TWI
Japan	Tokyo Stock Exchange	NIKKEI 225
China	Shanghai Stock Exchange	SSE
Indonesia	Jakarta Stock Exchange	JFX
USA	New York Stock Exchange	S&P 500
United Kingdom	London Stock Exchange	FTSE

#### 4. Empirical Results and Discussion

To assess the distributional properties of stock market return series of emerging markets, descriptive statistics are reported in Table 2. The average daily returns of emerging stock markets are found to be positive and ranges between 0.002 and 0.07 percent. The Indonesian market provides the highest return with an average of 0.07 percent, followed by Indian market, recording an average of 0.05 percent. The major stock markets of China, South Korea, Malaysia and Japan recorded average returns of 0.02 percent, respectively. The lowest mean returns are observed for the United Kingdom, Taiwan and the United States. Furthermore, the summary statistics show that the stock markets display a wide level of standard deviation ranging from 0.012 (Malaysia) to 0.020 (South Korea) during the sample period. All stock market returns, with an exception of Singapore, exhibit negative skewness, which implies that their distributions have a long left tail. The kurtosis statistics of all stock market return series exhibits more than three, implying that returns do not follow a normal distribution. In addition, the market return series are non-normal according to the Jarque-Bera test, which rejects normality at one per cent level.

**Table 2: Descriptive Statistics**

Statistics	S&P 500	TWI	STI	SSE	KLSE	KOSPI	NIKKEI 225	JFX	NIFTY	HSI	FTSE
Mean	0.00003	0.00003	0.0001	0.0002	0.0002	0.0002	0.0002	0.0007	0.0005	0.0001	0.00002
Median	0.0006	0.0005	0.0004	0.0001	0.0004	0.0009	0.00008	0.0021	0.0011	0.0004	0.0003
Max.	0.0940	0.1607	0.2147	0.0932	0.1986	0.1386	0.0998	0.1362	0.1633	0.1680	0.0982
Min.	-0.1379	-0.1260	-0.1494	-0.1416	-0.1924	-0.1677	-0.1271	-0.1360	-0.2199	-0.1597	-0.1032
Std. Dev.	0.0150	0.0179	0.0152	0.0184	0.0120	0.0201	0.0173	0.0171	0.0192	0.0181	0.0145
Skewness	-0.4594	-0.1250	0.6228	-0.1115	-0.5559	-0.4761	-0.6632	-0.6105	-0.7902	-0.1852	-0.0302
Kurtosis	10.23	10.08	27.04	8.00	64.65	9.98	9.37	13.31	16.18	13.23	8.68
J-B	5506.7*	5216.1*	60164*	2603.1*	394603*	5153.1*	4402.3*	11197*	18289*	10877*	3358*

Notes: J-B is a Jarque-Bera statistic to test for normality. \* -denote the significance at one percent level.

Table 3 reports the correlation coefficients of the major stock market returns of emerging economies. The table result indicates that the coefficients of correlation across the stock market returns are positive and strong linkages were detected between Taiwan and

other markets such as Singapore, South Korea, Japan and Hong Kong, showing correlation coefficients in a range between 0.5195 and 0.6181. Singapore stock market exhibits profound correlations with Hong Kong, South Korea, Japan, India, Indonesia, and the United Kingdom, ranging between 0.5071 and 0.7634. Besides, the South Korean market is strongly associated to Japan and Hong Kong stock markets, with coefficients of 0.6197 and 0.6489, respectively. The result also reveals that the Hong Kong stock market is strongly correlated with Japan, Indonesia and India. Similarly, the United States market is highly linked with the United Kingdom stock market. However, the correlations among other market returns are considered to be low.

**Table 3: Correlation Matrix for the Stock Market Returns**

Stock Indexes	S&P 500	TWI	STI	SSE	KLSE	KOSPI	NIKKEI 225	JFX	NIFTY	HSI	FTSE
<b>S&amp;P 500</b>	1.0000										
<b>TWI</b>	0.2502	1.0000									
<b>STI</b>	0.3675	0.5701	1.0000								
<b>SSE</b>	0.0656	0.1896	0.2466	1.0000							
<b>KLSE</b>	0.1191	0.3481	0.4359	0.1914	1.0000						
<b>KOSPI</b>	0.2983	0.6181	0.6216	0.1839	0.3611	1.0000					
<b>NIKKEI 225</b>	0.2754	0.5195	0.5943	0.2173	0.3495	0.6197	1.0000				
<b>JFX</b>	0.2051	0.4561	0.5519	0.2204	0.3836	0.4565	0.4349	1.0000			
<b>NIFTY</b>	0.2700	0.3977	0.5593	0.2061	0.2988	0.4587	0.4096	0.4628	1.0000		
<b>HSI</b>	0.3306	0.5673	0.7634	0.3389	0.4045	0.6489	0.6334	0.5423	0.5632	1.0000	
<b>FTSE</b>	0.6299	0.3570	0.5071	0.1355	0.2288	0.3964	0.4315	0.3364	0.4018	0.4948	1.0000

A prerequisite for testing cointegration between stock market returns is that all variables are non-stationary. The Augmented Dickey Fuller (ADF) test with intercept is employed to check whether the variables contain a unit root or not. Table 4 reports the results of ADF unit root test for the major stock market indexes of emerging economies, namely India, Malaysia, Hong Kong, Singapore, South Korea, Taiwan, Japan, China, Indonesia, the United States and the United Kingdom. The results reveal that all the stock indexes are stationary at the first differences, and hence they are integrated in the order of I(1).

**Table 4: Unit root test Results**

<b>Augmented Dickey-Fuller Test</b>		
<b>Variables</b>	<b>Level</b>	<b>First Difference</b>
HIS	-1.332	-50.87*
JFX	0.255	-46.45*
KLSE	-0.476	-51.39*
KOSPI	-0.811	-51.11*
NIKKEI	-2.365	-50.53*
225		
NSE	-0.453	-49.24*
S&P500	-2.043	-53.45*
SSE	-1.426	-50.06*
STI	-1.078	-50.18*
TWI	-2.177	-48.33*
FTSE	-2.447	-51.92*
Notes: * – indicates significance at one percent level. Optimal lag length is determined by the Schwarz Information Criterion (SIC).		

Johansen and Juselius (1990) multivariate cointegration test was performed to examine the long-run relationship between the major stock markets of emerging Asia-Pacific economies and the results are reported in Table 5. Both trace and maximum eigen value indicates the presence of single cointegrating vector among all the stock markets at five percent significant level. This implies that there is a well defined long-run equilibrium relationship among the major stock markets, which suggests the stock market indexes move together and have high correlation in the long run, so there are limited benefits from portfolio diversification across the stock markets in the long run. By and large, the cointegrated stock markets imply that there is a common force, such as arbitrage activity, which brings the stock markets together in the long run. These findings are consistent with the results of Jang and Sul (2002) and Choudhry and Lin (2004), who found a significant long-run relationship between the emerging Asian equity markets.

**Table 5: Johansen Maximum Likelihood Cointegration test**

<b>Null Hypothesis</b>	<b>Alternative Hypothesis</b>	<b>Trace Statistics</b>	<b>5% Critical Value</b>	<b>Max Eigen statistics</b>	<b>5% Critical Value</b>
$H_0: r = 0$	$H_1: r = 1$	308.42**	285.14**	73.1552	70.53
$H_0: r \leq 1$	$H_1: r = 2$	235.26	239.23	59.9463	64.50
$H_0: r \leq 2$	$H_1: r = 3$	175.32	197.37	54.1847	58.43
$H_0: r \leq 3$	$H_1: r = 4$	121.13	159.52	33.5259	52.36
$H_0: r \leq 4$	$H_1: r = 5$	87.61	125.61	26.7449	46.23
$H_0: r \leq 5$	$H_1: r = 6$	60.86	95.75	22.4532	40.07
$H_0: r \leq 6$	$H_1: r = 7$	38.41	69.81	13.4763	33.87
$H_0: r \leq 7$	$H_1: r = 8$	24.93	47.85	10.2109	27.58
$H_0: r \leq 8$	$H_1: r = 9$	14.72	29.79	8.5068	21.13
$H_0: r \leq 9$	$H_1: r = 10$	6.217	15.49	5.8904	14.26
$H_0: r \leq 10$	$H_1: r = 11$	0.329	3.841	0.3292	3.841

Notes: r is the number of cointegrating vector. Critical values are noted from MacKinnon-Haug-Michelis (1999), and \*\* - denote the significance at five percent level.

The results of the estimated multivariate Vector Error Correction Model (VECM) are presented in Table 6. As already proved by cointegration test, the stock market prices are cointegrated, i.e., there is a well defined long-run equilibrium relationship between the major stock markets. The long-run dynamics was examined through the effect of the lagged error correction term in the VEC model. Table 6 results clearly show significant error correction terms with negative sign for all the major stock market returns except the United States market. This implies that these major stock markets are significantly adjusted to disequilibrium from the long-run relationship or the response with which the previous period's deviations from the long-run relationship are corrected is found to be significant in these major stock markets. The empirical results reveal that all the major stock market returns of emerging economies are significantly influenced by each other, suggesting a stronger long-run bilateral relationship between major stock markets of India, Malaysia, Hong Kong, Singapore, South Korea, Taiwan, Japan, China, Indonesia, the United States and the United Kingdom.

**Table 6: Short-run Causality Results based on VEC Granger Causality/Block Exogeneity Wald test**

Dependent Variable	$\Delta$ NIFTY	$\Delta$ JFX	$\Delta$ NIKKEI 225	$\Delta$ KOSPI	$\Delta$ FTSE	$\Delta$ KLSE	$\Delta$ SSE	$\Delta$ STI	$\Delta$ HSI	$\Delta$ TWI	$\Delta$ S&P 500
Wald $\chi^2$ Statistics											
$\Delta$ NIFTY	--	21.82*	3.005	5.210	35.70*	1.839	8.260**	13.81*	0.573	6.151	17.87*
$\Delta$ JFX	7.296***	--	8.595**	11.90*	97.15*	3.208	8.285**	2.258	13.66*	11.24*	57.41*
$\Delta$ NIKKEI 225	9.967**	15.77*	--	7.439***	176.75*	19.75*	17.40*	2.647	14.55*	8.919**	62.20*
$\Delta$ KOSPI	7.295***	17.92*	8.743**	--	170.93*	19.25*	14.25*	6.093	3.367	26.15*	83.00*
$\Delta$ FTSE	12.06*	3.505	15.71*	2.557	--	15.17*	8.902**	6.821***	29.76*	70.70*	89.52*
$\Delta$ KLSE	2.188	15.76*	5.998	1.903	33.04*	--	7.222***	0.306	1.808	10.60**	13.73*
$\Delta$ SSE	1.172	4.508	1.181	10.25**	15.02*	1.244	--	1.015	4.926	4.720	2.363
$\Delta$ STI	12.64*	2.544	13.35*	2.323	111.93*	10.92**	5.667	--	2.513	20.70*	80.81*
$\Delta$ HSI	15.21*	2.940	8.242**	4.865	172.86*	6.253***	17.83*	3.999	--	19.96*	92.45*
$\Delta$ TWI	9.217**	5.982	27.92*	3.170	169.38*	16.34*	12.65*	10.82**	2.487	--	126.48*
$\Delta$ S&P 500	17.35*	15.33*	13.97*	13.95*	17.88*	10.15**	5.778	2.303	2.625	5.771	--

Note:  $\Delta$  implies first difference operator. Optimal lag length was determined by Final prediction error criterion (FPE) and Akaike information criterion (AIC). \*, \*\* and \*\*\* - denote the significance at one, five and ten percent level, respectively.



**Table 7: Vector Error Correction Model Estimates**

	$\Delta$ NIFTY	$\Delta$ JFX	$\Delta$ NIKKEI 225	$\Delta$ KOSPI	$\Delta$ FTSE	$\Delta$ KLSE	$\Delta$ SSE	$\Delta$ STI	$\Delta$ HSI	$\Delta$ TWI	$\Delta$ S&P 500
$Z_{t-1}$	-0.0902* (-6.275)	-0.1398* (-11.21)	-0.1648* (-13.90)	-0.1869* (-13.15)	-0.1488* (-14.20)	-0.0558* (-6.201)	-0.0354** (-2.526)	-0.1754* (-14.13)	-0.1394* (-12.88)	-0.1980* (-15.46)	0.0662* (5.794)
Constant	-0.00006 (-0.014)	-0.00007 (-0.020)	-0.00002 (-0.064)	-0.00003 (-0.007)	-0.00003 (-0.012)	-0.00001 (-0.068)	-0.00003 (-0.095)	-0.00001 (-0.048)	-0.00005 (-0.018)	-0.00002 (-0.074)	-0.00003 (0.104)

Note: \*, (\*\*) - denote the significance at one and five percent level, respectively.

**Table 8: Variance Decomposition Analysis**

Variance Decomposition of $\Delta$ SSE												
Days	S.E.	$\Delta$ HSI	$\Delta$ NIFTY	$\Delta$ JFX	$\Delta$ NEKKEI 225	$\Delta$ KOSPI	$\Delta$ FTSE	$\Delta$ KLSE	$\Delta$ SSE	$\Delta$ STI	$\Delta$ TWI	$\Delta$ S&P 500
1	0.02	9.64	0.04	0.18	0.00	0.29	0.02	0.33	89.51	0.00	0.00	0.00
2	0.02	9.83	0.14	0.26	0.10	0.30	0.71	0.31	87.80	0.01	0.00	0.55
3	0.02	9.72	0.16	0.24	0.13	0.57	0.73	0.34	87.45	0.04	0.01	0.63
4	0.02	10.03	0.14	0.27	0.12	0.76	0.66	0.32	87.03	0.03	0.05	0.59
5	0.03	9.64	0.16	0.23	0.11	0.65	0.57	0.32	87.44	0.03	0.10	0.74
6	0.03	9.92	0.18	0.27	0.13	0.71	0.57	0.31	87.03	0.04	0.10	0.74
7	0.03	9.92	0.18	0.26	0.14	0.79	0.52	0.31	87.02	0.04	0.09	0.75
8	0.03	9.95	0.18	0.25	0.14	0.80	0.49	0.31	87.01	0.04	0.08	0.76
9	0.03	9.96	0.19	0.25	0.14	0.78	0.46	0.31	87.03	0.04	0.08	0.78
10	0.03	10.01	0.19	0.25	0.14	0.81	0.44	0.30	86.96	0.04	0.07	0.80
11	0.03	10.02	0.19	0.24	0.14	0.82	0.41	0.30	86.96	0.04	0.07	0.80
12	0.03	10.04	0.20	0.24	0.14	0.82	0.40	0.30	86.95	0.04	0.06	0.81
13	0.03	10.06	0.20	0.24	0.15	0.83	0.38	0.30	86.94	0.04	0.06	0.82
14	0.04	10.07	0.20	0.24	0.15	0.84	0.36	0.30	86.93	0.04	0.06	0.83

15	0.04	10.09	0.20	0.24	0.15	0.84	0.35	0.30	86.92	0.04	0.05	0.83
16	0.04	10.10	0.20	0.23	0.15	0.84	0.34	0.30	86.91	0.04	0.05	0.84
17	0.04	10.11	0.21	0.23	0.15	0.85	0.33	0.29	86.90	0.04	0.05	0.84
18	0.04	10.12	0.21	0.23	0.15	0.85	0.32	0.29	86.90	0.04	0.05	0.85
19	0.04	10.13	0.21	0.23	0.15	0.86	0.31	0.29	86.89	0.03	0.05	0.85
20	0.04	10.14	0.21	0.23	0.15	0.86	0.30	0.29	86.89	0.03	0.04	0.86

**Variance Decomposition of  $\Delta$ KLSE**

<b>Days</b>	<b>S.E.</b>	<b><math>\Delta</math>HSI</b>	<b><math>\Delta</math>NIFTY</b>	<b><math>\Delta</math>JFX</b>	<b><math>\Delta</math>NEKKEI 225</b>	<b><math>\Delta</math>KOSPI</b>	<b><math>\Delta</math>FTSE</b>	<b><math>\Delta</math>KLSE</b>	<b><math>\Delta</math>SSE</b>	<b><math>\Delta</math>STI</b>	<b><math>\Delta</math>TWI</b>	<b><math>\Delta</math>S&amp;P 500</b>
1	0.01	10.88	0.77	2.60	0.60	0.49	0.01	84.66	0.00	0.00	0.00	0.00
2	0.01	10.68	1.23	2.96	0.61	0.53	1.30	79.43	0.08	0.03	0.00	3.14
3	0.01	10.72	1.28	2.99	0.59	0.53	1.26	78.97	0.11	0.03	0.00	3.51
4	0.02	10.70	1.46	2.77	0.53	0.54	1.19	78.52	0.13	0.03	0.05	4.09
5	0.02	10.10	1.44	2.58	0.55	0.51	1.03	79.54	0.12	0.03	0.05	4.07
6	0.02	10.47	1.53	2.84	0.55	0.54	1.24	78.37	0.12	0.03	0.04	4.28
7	0.02	10.46	1.57	2.81	0.53	0.54	1.19	78.23	0.11	0.03	0.04	4.49
8	0.02	10.46	1.64	2.78	0.52	0.55	1.15	78.13	0.10	0.02	0.04	4.61
9	0.02	10.38	1.67	2.73	0.51	0.54	1.12	78.18	0.09	0.03	0.04	4.71
10	0.02	10.44	1.70	2.77	0.51	0.55	1.12	77.91	0.09	0.02	0.04	4.86
11	0.02	10.44	1.73	2.76	0.50	0.55	1.10	77.84	0.08	0.02	0.04	4.94
12	0.02	10.43	1.76	2.75	0.49	0.56	1.08	77.77	0.08	0.02	0.04	5.02
13	0.02	10.43	1.78	2.74	0.49	0.56	1.07	77.72	0.07	0.02	0.04	5.09
14	0.02	10.43	1.80	2.74	0.48	0.56	1.06	77.63	0.07	0.02	0.04	5.16
15	0.02	10.43	1.82	2.74	0.48	0.56	1.05	77.58	0.07	0.02	0.04	5.22
16	0.02	10.43	1.84	2.73	0.48	0.56	1.04	77.53	0.06	0.02	0.04	5.27
17	0.02	10.43	1.85	2.73	0.47	0.56	1.04	77.48	0.06	0.02	0.04	5.32
18	0.03	10.43	1.86	2.73	0.47	0.57	1.03	77.44	0.06	0.02	0.04	5.36
19	0.03	10.43	1.88	2.73	0.47	0.57	1.02	77.40	0.06	0.02	0.04	5.40
20	0.03	10.43	1.89	2.72	0.46	0.57	1.02	77.36	0.06	0.02	0.04	5.44

Variance Decomposition of $\Delta JFX$												
Days	S.E.	$\Delta HSI$	$\Delta NIFTY$	$\Delta JFX$	$\Delta NEKKEI$ 225	$\Delta KOSPI$	$\Delta FTSE$	$\Delta KLSE$	$\Delta SSE$	$\Delta STI$	$\Delta TWI$	$\Delta S\&P$ 500
1	0.02	23.20	3.67	73.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	20.41	4.96	67.41	0.07	0.01	1.20	0.07	0.01	0.01	0.22	5.62
3	0.02	19.81	5.86	66.42	0.07	0.05	1.12	0.11	0.01	0.01	0.29	6.26
4	0.02	20.27	6.17	64.15	0.23	0.11	1.17	0.16	0.04	0.04	0.27	7.39
5	0.02	19.03	6.03	64.76	0.21	0.10	1.02	0.14	0.07	0.03	0.38	8.23
6	0.02	18.81	6.48	64.44	0.20	0.09	1.19	0.15	0.07	0.03	0.38	8.15
7	0.03	18.63	6.87	63.87	0.21	0.08	1.13	0.16	0.06	0.03	0.40	8.56
8	0.03	18.64	6.98	63.43	0.23	0.08	1.11	0.16	0.06	0.03	0.39	8.89
9	0.03	18.32	7.07	63.39	0.22	0.07	1.08	0.16	0.06	0.03	0.42	9.18
10	0.03	18.17	7.26	63.14	0.23	0.07	1.07	0.16	0.06	0.03	0.43	9.39
11	0.03	18.08	7.41	62.94	0.23	0.06	1.04	0.16	0.05	0.03	0.43	9.56
12	0.03	17.99	7.50	62.78	0.23	0.06	1.03	0.16	0.05	0.03	0.44	9.74
13	0.03	17.88	7.59	62.66	0.23	0.06	1.01	0.16	0.05	0.03	0.45	9.89
14	0.03	17.80	7.68	62.53	0.24	0.05	1.00	0.16	0.05	0.03	0.45	10.02
15	0.03	17.72	7.76	62.41	0.24	0.05	0.99	0.16	0.04	0.03	0.46	10.14
16	0.03	17.66	7.83	62.31	0.24	0.05	0.98	0.16	0.04	0.03	0.46	10.25
17	0.04	17.59	7.89	62.22	0.24	0.05	0.97	0.16	0.04	0.03	0.46	10.35
18	0.04	17.53	7.95	62.14	0.24	0.04	0.96	0.16	0.04	0.03	0.47	10.44
19	0.04	17.48	8.01	62.06	0.24	0.04	0.95	0.16	0.04	0.03	0.47	10.52
20	0.04	17.44	8.05	61.99	0.24	0.04	0.94	0.17	0.03	0.03	0.47	10.60
Variance Decomposition of $\Delta NEKKEI$ 225												
Days	S.E.	$\Delta HSI$	$\Delta NIFTY$	$\Delta JFX$	$\Delta NEKKEI$ 225	$\Delta KOSPI$	$\Delta FTSE$	$\Delta KLSE$	$\Delta SSE$	$\Delta STI$	$\Delta TWI$	$\Delta S\&P$ 500
1	0.02	29.59	0.49	0.67	69.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	24.93	1.33	0.53	54.87	0.01	5.28	0.48	0.17	0.12	0.46	11.83
3	0.02	24.21	1.49	0.52	54.91	0.07	4.93	0.46	0.26	0.14	0.46	12.56

4	0.02	23.71	1.45	0.53	54.53	0.19	4.57	0.69	0.24	0.13	0.53	13.42
5	0.02	23.05	1.50	0.47	54.99	0.18	4.01	0.60	0.21	0.13	0.63	14.24
6	0.02	23.51	1.64	0.49	53.64	0.16	4.61	0.63	0.20	0.12	0.65	14.35
7	0.03	23.19	1.70	0.46	53.53	0.17	4.39	0.63	0.20	0.11	0.65	14.96
8	0.03	23.04	1.72	0.43	53.47	0.17	4.24	0.65	0.18	0.10	0.67	15.33
9	0.03	22.94	1.77	0.40	53.36	0.16	4.10	0.63	0.17	0.10	0.71	15.67
10	0.03	22.92	1.81	0.37	53.04	0.16	4.09	0.63	0.16	0.09	0.73	16.01
11	0.03	22.83	1.84	0.35	52.97	0.16	4.00	0.63	0.15	0.09	0.73	16.26
12	0.03	22.76	1.86	0.33	52.89	0.15	3.92	0.63	0.14	0.08	0.75	16.48
13	0.03	22.72	1.89	0.31	52.78	0.15	3.86	0.62	0.13	0.08	0.76	16.69
14	0.03	22.68	1.91	0.30	52.68	0.15	3.82	0.62	0.13	0.07	0.77	16.88
15	0.03	22.63	1.93	0.28	52.60	0.15	3.77	0.62	0.12	0.07	0.78	17.05
16	0.03	22.59	1.95	0.27	52.54	0.14	3.72	0.62	0.12	0.07	0.79	17.20
17	0.03	22.56	1.97	0.26	52.47	0.14	3.69	0.62	0.11	0.06	0.80	17.33
18	0.04	22.53	1.98	0.25	52.41	0.14	3.65	0.62	0.11	0.06	0.80	17.46
19	0.04	22.50	2.00	0.24	52.35	0.14	3.62	0.62	0.10	0.06	0.81	17.58
20	0.04	22.47	2.01	0.23	52.31	0.14	3.59	0.61	0.10	0.06	0.82	17.68

#### Variance Decomposition of $\Delta$ KOSPI

Days	S.E.	$\Delta$ HSI	$\Delta$ NIFTY	$\Delta$ JFX	$\Delta$ NEKKEI 225	$\Delta$ KOSPI	$\Delta$ FTSE	$\Delta$ KLSE	$\Delta$ SSE	$\Delta$ STI	$\Delta$ TWI	$\Delta$ S&P 500
1	0.02	32.85	1.30	0.74	7.24	57.86	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	28.85	2.36	0.63	6.23	50.66	3.12	0.47	0.08	0.28	0.08	7.24
3	0.02	28.10	2.39	1.07	6.20	49.86	3.08	0.58	0.24	0.26	0.13	8.08
4	0.03	27.38	2.31	1.10	5.89	49.29	2.98	0.68	0.22	0.28	0.13	9.74
5	0.03	26.06	2.47	0.94	5.72	50.20	2.55	0.58	0.21	0.24	0.26	10.77
6	0.03	26.24	2.68	0.87	5.68	49.31	3.15	0.67	0.20	0.24	0.26	10.70
7	0.03	25.90	2.71	0.91	5.61	49.04	3.06	0.68	0.19	0.23	0.28	11.39
8	0.03	25.65	2.71	0.86	5.50	49.03	2.98	0.70	0.18	0.23	0.27	11.90
9	0.03	25.37	2.79	0.81	5.46	49.06	2.86	0.69	0.18	0.22	0.30	12.27

10	0.03	25.25	2.86	0.77	5.41	48.82	2.90	0.71	0.17	0.21	0.31	12.59
11	0.03	25.12	2.89	0.75	5.37	48.77	2.85	0.71	0.16	0.21	0.31	12.88
12	0.03	24.99	2.91	0.72	5.32	48.72	2.82	0.71	0.15	0.21	0.31	13.15
13	0.04	24.86	2.95	0.69	5.29	48.67	2.78	0.72	0.15	0.20	0.32	13.37
14	0.04	24.77	2.98	0.66	5.26	48.60	2.76	0.72	0.14	0.20	0.33	13.58
15	0.04	24.67	3.00	0.64	5.23	48.56	2.74	0.73	0.14	0.20	0.33	13.77
16	0.04	24.59	3.02	0.63	5.21	48.51	2.72	0.73	0.13	0.19	0.34	13.94
17	0.04	24.51	3.05	0.61	5.19	48.48	2.69	0.73	0.13	0.19	0.34	14.09
18	0.04	24.44	3.07	0.59	5.16	48.44	2.68	0.74	0.12	0.19	0.35	14.23
19	0.04	24.38	3.08	0.58	5.14	48.41	2.66	0.74	0.12	0.19	0.35	14.36
20	0.04	24.32	3.10	0.57	5.13	48.38	2.65	0.74	0.12	0.18	0.35	14.48

**Variance Decomposition of  $\Delta$ FTSE**

<b>Days</b>	<b>S.E.</b>	<b><math>\Delta</math>HSI</b>	<b><math>\Delta</math>NIFTY</b>	<b><math>\Delta</math>JFX</b>	<b><math>\Delta</math>NEKKEI 225</b>	<b><math>\Delta</math>KOSPI</b>	<b><math>\Delta</math>FTSE</b>	<b><math>\Delta</math>KLSE</b>	<b><math>\Delta</math>ASSE</b>	<b><math>\Delta</math>STI</b>	<b><math>\Delta</math>TWI</b>	<b><math>\Delta</math>S&amp;P 500</b>
1	0.02	18.32	2.67	0.18	1.81	0.06	76.96	0.00	0.00	0.00	0.00	0.00
2	0.02	15.49	2.55	0.57	1.52	0.18	68.06	0.30	0.00	0.03	0.05	11.26
3	0.02	14.57	2.65	0.54	1.47	0.22	68.55	0.40	0.24	0.03	0.07	11.25
4	0.02	13.70	2.75	0.82	1.34	0.26	68.76	0.44	0.28	0.08	0.31	11.25
5	0.02	13.50	2.84	0.72	1.27	0.23	68.36	0.38	0.24	0.11	0.27	12.08
6	0.02	13.12	2.83	0.68	1.22	0.28	68.57	0.46	0.25	0.11	0.27	12.20
7	0.02	12.57	2.92	0.69	1.18	0.28	68.87	0.48	0.28	0.11	0.26	12.38
8	0.02	12.28	2.98	0.72	1.12	0.26	68.96	0.48	0.27	0.10	0.26	12.57
9	0.02	12.04	3.00	0.69	1.09	0.25	69.02	0.46	0.27	0.10	0.24	12.85
10	0.02	11.77	3.02	0.68	1.06	0.26	69.16	0.47	0.27	0.09	0.22	13.00
11	0.02	11.53	3.06	0.68	1.03	0.25	69.30	0.48	0.27	0.09	0.21	13.10
12	0.03	11.36	3.09	0.68	1.00	0.25	69.36	0.48	0.27	0.09	0.20	13.24
13	0.03	11.19	3.11	0.67	0.98	0.24	69.45	0.47	0.27	0.08	0.19	13.35
14	0.03	11.03	3.13	0.66	0.96	0.24	69.53	0.48	0.27	0.08	0.18	13.45
15	0.03	10.89	3.15	0.66	0.95	0.24	69.59	0.48	0.27	0.08	0.17	13.54

16	0.03	10.76	3.16	0.66	0.93	0.24	69.65	0.48	0.27	0.08	0.17	13.62
17	0.03	10.65	3.18	0.65	0.91	0.24	69.71	0.48	0.27	0.07	0.16	13.69
18	0.03	10.54	3.19	0.65	0.90	0.23	69.76	0.48	0.27	0.07	0.15	13.76
19	0.03	10.44	3.21	0.65	0.89	0.23	69.80	0.48	0.27	0.07	0.15	13.82
20	0.03	10.35	3.22	0.65	0.88	0.23	69.85	0.48	0.27	0.07	0.14	13.88

**Variance Decomposition of  $\Delta$ HSI**

<b>Days</b>	<b>S.E.</b>	<b><math>\Delta</math>HSI</b>	<b><math>\Delta</math>NIFTY</b>	<b><math>\Delta</math>JFX</b>	<b><math>\Delta</math>NEKKEI 225</b>	<b><math>\Delta</math>KOSPI</b>	<b><math>\Delta</math>FTSE</b>	<b><math>\Delta</math>KLSE</b>	<b><math>\Delta</math>ASSE</b>	<b><math>\Delta</math>STI</b>	<b><math>\Delta</math>TWI</b>	<b><math>\Delta</math>S&amp;P 500</b>
1	0.02	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	82.55	0.57	0.14	0.14	0.03	4.41	0.13	0.18	0.23	0.21	11.40
3	0.02	81.20	0.72	0.36	0.15	0.16	4.15	0.20	0.17	0.21	0.21	12.45
4	0.02	80.65	0.70	0.57	0.38	0.34	3.80	0.28	0.16	0.19	0.20	12.72
5	0.02	80.13	0.63	0.69	0.34	0.31	3.33	0.25	0.14	0.18	0.38	13.61
6	0.02	79.18	0.73	0.63	0.35	0.34	4.09	0.27	0.17	0.18	0.36	13.69
7	0.03	78.65	0.76	0.72	0.36	0.37	3.87	0.28	0.15	0.17	0.35	14.29
8	0.03	78.42	0.76	0.77	0.39	0.37	3.73	0.29	0.14	0.16	0.35	14.62
9	0.03	78.19	0.76	0.81	0.39	0.35	3.60	0.28	0.13	0.16	0.38	14.93
10	0.03	77.83	0.78	0.81	0.40	0.36	3.63	0.29	0.13	0.15	0.38	15.23
11	0.03	77.66	0.78	0.84	0.40	0.37	3.53	0.29	0.12	0.15	0.37	15.47
12	0.03	77.50	0.79	0.86	0.41	0.37	3.47	0.29	0.11	0.14	0.38	15.67
13	0.03	77.34	0.79	0.89	0.41	0.36	3.42	0.29	0.11	0.14	0.39	15.86
14	0.03	77.18	0.80	0.90	0.42	0.37	3.38	0.29	0.10	0.14	0.38	16.04
15	0.03	77.05	0.80	0.91	0.42	0.37	3.34	0.29	0.10	0.13	0.39	16.19
16	0.03	76.94	0.81	0.92	0.42	0.37	3.30	0.29	0.10	0.13	0.39	16.33
17	0.03	76.83	0.81	0.94	0.43	0.37	3.26	0.29	0.09	0.13	0.39	16.46
18	0.04	76.73	0.82	0.95	0.43	0.37	3.23	0.29	0.09	0.12	0.39	16.57
19	0.04	76.64	0.82	0.96	0.43	0.37	3.20	0.29	0.09	0.12	0.39	16.68
20	0.04	76.56	0.82	0.96	0.44	0.37	3.18	0.29	0.08	0.12	0.39	16.78

Variance Decomposition of $\Delta$ NIFTY												
Days	S.E.	$\Delta$ HSI	$\Delta$ NIFTY	$\Delta$ JFX	$\Delta$ NEKKEI 225	$\Delta$ KOSPI	$\Delta$ FTSE	$\Delta$ KLSE	$\Delta$ SSE	$\Delta$ STI	$\Delta$ TWI	$\Delta$ S&P 500
1	0.02	28.63	71.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.02	26.68	69.08	0.34	0.00	0.10	0.88	0.00	0.12	0.08	0.04	2.66
3	0.02	26.20	68.81	0.58	0.00	0.09	1.12	0.01	0.17	0.07	0.08	2.85
4	0.02	25.96	68.20	1.21	0.02	0.10	1.03	0.04	0.15	0.31	0.08	2.88
5	0.03	24.91	69.41	1.03	0.02	0.08	0.88	0.03	0.13	0.30	0.12	3.08
6	0.03	24.93	69.16	1.04	0.02	0.09	1.14	0.03	0.13	0.29	0.12	3.06
7	0.03	24.72	69.15	1.15	0.02	0.08	1.15	0.03	0.12	0.28	0.12	3.18
8	0.03	24.64	69.14	1.24	0.02	0.07	1.10	0.04	0.11	0.29	0.11	3.23
9	0.03	24.34	69.50	1.20	0.02	0.07	1.05	0.03	0.10	0.27	0.11	3.30
10	0.03	24.29	69.48	1.22	0.02	0.06	1.08	0.03	0.10	0.26	0.12	3.35
11	0.03	24.19	69.53	1.25	0.02	0.06	1.07	0.03	0.09	0.25	0.11	3.38
12	0.03	24.11	69.59	1.27	0.02	0.06	1.05	0.03	0.09	0.24	0.11	3.42
13	0.04	24.00	69.70	1.28	0.02	0.05	1.04	0.03	0.08	0.24	0.11	3.45
14	0.04	23.95	69.73	1.29	0.01	0.05	1.04	0.03	0.08	0.23	0.11	3.48
15	0.04	23.88	69.77	1.30	0.01	0.05	1.03	0.03	0.07	0.22	0.11	3.51
16	0.04	23.82	69.82	1.31	0.01	0.05	1.02	0.03	0.07	0.22	0.11	3.53
17	0.04	23.77	69.86	1.31	0.01	0.05	1.02	0.03	0.07	0.21	0.11	3.55
18	0.04	23.72	69.89	1.32	0.01	0.04	1.01	0.03	0.06	0.21	0.11	3.57
19	0.04	23.68	69.93	1.33	0.01	0.04	1.01	0.03	0.06	0.21	0.11	3.59
20	0.04	23.64	69.96	1.34	0.01	0.04	1.00	0.03	0.06	0.20	0.11	3.61
Variance Decomposition of $\Delta$ STI												
Days	S.E.	$\Delta$ HSI	$\Delta$ NIFTY	$\Delta$ JFX	$\Delta$ NEKKEI 225	$\Delta$ KOSPI	$\Delta$ FTSE	$\Delta$ KLSE	$\Delta$ SSE	$\Delta$ STI	$\Delta$ TWI	$\Delta$ S&P 500
1	0.02	51.36	2.75	1.76	1.68	1.09	0.74	0.69	0.01	39.93	0.00	0.00
2	0.02	43.94	3.09	1.52	1.43	0.93	2.72	0.67	0.03	36.59	0.14	8.94
3	0.02	43.37	3.52	1.41	1.41	0.89	2.71	0.62	0.07	36.17	0.13	9.71

4	0.02	42.37	3.55	1.31	1.28	0.80	2.78	0.57	0.06	36.89	0.12	10.28
5	0.02	41.42	3.62	1.16	1.30	0.86	2.43	0.65	0.06	37.73	0.26	10.52
6	0.02	40.72	3.81	1.09	1.27	0.81	3.07	0.60	0.05	37.58	0.24	10.76
7	0.02	40.29	3.97	1.01	1.23	0.79	3.03	0.56	0.06	37.57	0.23	11.28
8	0.02	39.91	4.02	0.93	1.17	0.76	3.05	0.52	0.05	37.86	0.22	11.51
9	0.02	39.44	4.09	0.86	1.16	0.74	2.99	0.49	0.05	38.20	0.24	11.73
10	0.03	39.13	4.18	0.81	1.13	0.72	3.10	0.46	0.05	38.18	0.24	12.01
11	0.03	38.90	4.25	0.76	1.11	0.71	3.09	0.43	0.05	38.28	0.23	12.20
12	0.03	38.66	4.29	0.72	1.09	0.69	3.11	0.41	0.04	38.41	0.23	12.36
13	0.03	38.41	4.35	0.68	1.07	0.68	3.11	0.39	0.04	38.54	0.23	12.50
14	0.03	38.23	4.39	0.65	1.06	0.67	3.13	0.37	0.04	38.58	0.23	12.65
15	0.03	38.06	4.43	0.62	1.04	0.66	3.13	0.35	0.04	38.66	0.23	12.78
16	0.03	37.90	4.47	0.59	1.03	0.65	3.14	0.34	0.04	38.74	0.22	12.89
17	0.03	37.75	4.50	0.56	1.02	0.64	3.15	0.33	0.04	38.80	0.22	12.99
18	0.03	37.63	4.53	0.54	1.01	0.63	3.16	0.31	0.03	38.85	0.22	13.09
19	0.03	37.51	4.56	0.52	1.00	0.63	3.16	0.30	0.03	38.91	0.22	13.17
20	0.03	37.39	4.59	0.50	0.99	0.62	3.17	0.29	0.03	38.95	0.22	13.25

#### Variance Decomposition of $\Delta TWI$

Days	S.E.	$\Delta HSI$	$\Delta NIFTY$	$\Delta JFX$	$\Delta NEKKEI$ 225	$\Delta KOSPI$	$\Delta FTSE$	$\Delta KLSE$	$\Delta SSE$	$\Delta STI$	$\Delta TWI$	$\Delta S\&P$ 500
1	0.02	23.71	0.71	2.24	3.03	6.75	0.03	0.18	0.01	1.01	62.33	0.00
2	0.02	20.93	1.86	1.90	2.80	5.93	1.60	0.24	0.05	1.57	54.58	8.53
3	0.02	19.94	2.13	1.92	2.83	5.71	1.60	0.36	0.08	1.45	53.64	10.35
4	0.02	18.71	2.11	1.74	2.62	5.31	1.46	0.42	0.12	1.67	53.12	12.72
5	0.02	18.11	2.14	1.53	2.51	5.51	1.29	0.42	0.12	1.58	52.87	13.93
6	0.03	18.14	2.39	1.41	2.63	5.36	1.48	0.41	0.11	1.66	52.41	14.01
7	0.03	17.74	2.49	1.30	2.62	5.28	1.45	0.40	0.10	1.64	52.03	14.94
8	0.03	17.41	2.51	1.20	2.55	5.22	1.42	0.39	0.10	1.70	51.95	15.56
9	0.03	17.16	2.57	1.12	2.54	5.17	1.37	0.36	0.10	1.70	51.83	16.08



10	0.03	16.99	2.66	1.04	2.54	5.11	1.37	0.35	0.10	1.71	51.59	16.54
11	0.03	16.82	2.70	0.98	2.53	5.08	1.36	0.34	0.10	1.72	51.47	16.92
12	0.03	16.67	2.73	0.92	2.51	5.04	1.34	0.33	0.10	1.73	51.38	17.26
13	0.03	16.53	2.77	0.87	2.51	5.01	1.33	0.32	0.09	1.74	51.29	17.56
14	0.03	16.41	2.81	0.82	2.50	4.98	1.32	0.31	0.09	1.75	51.18	17.83
15	0.03	16.30	2.84	0.78	2.49	4.95	1.31	0.30	0.09	1.75	51.10	18.08
16	0.04	16.20	2.86	0.75	2.49	4.93	1.30	0.29	0.09	1.76	51.03	18.30
17	0.04	16.11	2.89	0.71	2.48	4.91	1.29	0.28	0.09	1.77	50.97	18.50
18	0.04	16.03	2.91	0.68	2.48	4.89	1.29	0.28	0.09	1.77	50.91	18.68
19	0.04	15.96	2.93	0.66	2.47	4.87	1.28	0.27	0.09	1.78	50.85	18.85
20	0.04	15.89	2.95	0.63	2.47	4.86	1.27	0.27	0.09	1.78	50.80	19.01

**Variance Decomposition of  $\Delta$ S&P 500**

Days	S.E.	$\Delta$ HSI	$\Delta$ NIFTY	$\Delta$ JFX	$\Delta$ NEKKEI 225	$\Delta$ KOSPI	$\Delta$ FTSE	$\Delta$ KLSE	$\Delta$ SSE	$\Delta$ STI	$\Delta$ TWI	$\Delta$ S&P 500
1	0.02	16.46	0.83	0.10	2.29	0.75	32.81	0.15	0.13	0.25	0.19	46.05
2	0.02	16.57	0.88	0.24	2.27	0.79	33.47	0.51	0.16	0.25	0.37	44.50
3	0.02	16.68	0.97	0.25	2.90	0.74	33.86	0.57	0.15	0.26	0.56	43.08
4	0.02	16.96	0.93	0.26	2.73	0.85	34.50	0.66	0.15	0.30	0.52	42.14
5	0.02	18.64	0.86	0.41	3.16	0.80	35.26	0.58	0.14	0.27	0.73	39.17
6	0.02	18.42	0.94	0.40	3.13	0.74	35.77	0.77	0.13	0.26	0.76	38.69
7	0.02	18.56	0.97	0.38	3.24	0.71	36.15	0.79	0.12	0.26	0.82	38.01
8	0.02	18.86	0.96	0.35	3.22	0.69	36.54	0.82	0.12	0.26	0.82	37.37
9	0.02	19.10	0.94	0.33	3.32	0.67	36.84	0.80	0.11	0.26	0.86	36.78
10	0.02	19.23	0.96	0.31	3.34	0.64	37.23	0.85	0.11	0.25	0.89	36.18
11	0.02	19.36	0.97	0.30	3.38	0.62	37.47	0.86	0.10	0.25	0.92	35.78
12	0.03	19.51	0.97	0.28	3.40	0.61	37.70	0.87	0.10	0.25	0.93	35.38
13	0.03	19.62	0.97	0.27	3.44	0.59	37.93	0.88	0.09	0.25	0.95	35.02
14	0.03	19.73	0.98	0.25	3.46	0.57	38.13	0.89	0.09	0.25	0.97	34.68
15	0.03	19.82	0.98	0.24	3.48	0.56	38.31	0.90	0.09	0.25	0.98	34.40

16	0.03	19.91	0.98	0.23	3.50	0.55	38.47	0.91	0.08	0.24	1.00	34.13
17	0.03	19.99	0.98	0.22	3.52	0.54	38.62	0.92	0.08	0.24	1.01	33.88
18	0.03	20.07	0.98	0.21	3.53	0.53	38.76	0.93	0.08	0.24	1.02	33.65
19	0.03	20.13	0.99	0.20	3.55	0.52	38.88	0.93	0.08	0.24	1.03	33.45
20	0.03	20.20	0.99	0.20	3.56	0.51	39.00	0.94	0.08	0.24	1.04	33.25

Table 7 provides the results of Granger causality/Block exogeneity Wald test based on VECM to identify the short-run causality between the stock markets and to have an apparent inference of which market exert influence over the others. The empirical results confirm a unidirectional short-run causality running from Indian stock market to Hong Kong, Japan, Korea and Taiwan markets. The Chinese stock market exerts significant influence on Hong Kong, India, Indonesia, Japan, Malaysia and Taiwan stock markets. Besides, there is a one-way short-run unidirectional causation between Indonesia and Malaysia, Japan and Singapore and Hong Kong and Indonesia. The direction of causality is also observed from Malaysian stock market to Hong Kong, Japan, Korea and Singapore stock markets. The findings also indicated that stock markets of Hong Kong, Indonesia and Korea are significantly influenced by the Taiwan market. Moreover, one-way Granger causation is detected between the United States and Hong Kong, and between Singapore and Taiwan markets. As for the United Kingdom market, it does have a significant influence over Korea and Indonesia. Most importantly, it is evident from the test results that there exist short-run bidirectional relationships running between India and Indonesia, Indonesia and Japan, Indonesia and Korea, Japan and Korea, the United Kingdom and India, the United Kingdom and Japan, the United Kingdom and Malaysia, China and Korea, China and the United Kingdom, Singapore and India, Singapore and the United Kingdom, Japan and Taiwan, the United Kingdom and Taiwan, Malaysia and Taiwan, Taiwan and Singapore, the United States and India, Indonesia and the United States, Japan and the United States, Korea and the United States, the United Kingdom and the United States, Malaysia and the United States, Japan and Hong Kong and the United Kingdom and Hong Kong.

The results of Variance Decomposition Analysis based on VECM for the major stock markets of emerging Asia-Pacific economies over a 20-day horizon are presented in Table 8. The table result shows that Chinese stock market was 89.51 percent explained by its own shock on the first trading day, and then it continued to reduce to 86.89 percent on the 20<sup>th</sup> trading day. The shock of other equity markets on China ranges between 0.03 and 10.14 percent at the 20<sup>th</sup> day, indicating that the degree to which other major stock markets influence stock prices of China is petite. For the Malaysian market, about 77.36 percent of

the variation is explained by itself and shocks explained by other markets range between 0.01 and 23.64 percent on the 20<sup>th</sup> day. Moreover, the results confirm that majority of the stock markets viz. China (86.89 percent) followed by Malaysia (77.36 percent), Hong Kong (76.36 percent), India (69.96 percent), the United Kingdom (69.85 percent), Indonesia (61.99 percent), Japan (52.31 percent), Taiwan (50.80 percent), South Korea (48.38 percent), Singapore (38.95 percent), and the United States (33.25 percent) are said to be fairly exogenous markets, as they are explained by itself for its own shock on the 20<sup>th</sup> day. Furthermore, the Indonesia, Japan, South Korea, United Kingdom, Hong Kong, India, Singapore, Taiwan and United States accounts for 0.03 to 17.44 percent, 0.06 to 22.47 percent, 0.12 to 24.32 percent, 0.07 to 13.88 percent, 0.08 to 16.78 percent, 0.01 to 23.64 percent, 0.03 to 37.39 percent, 0.09 to 50.80 percent and 0.08 to 39.0 percent, respectively, of the shock explained by other markets on the 20<sup>th</sup> business day. The results of variance decomposition analysis suggest that there exists feasible opportunity for the short-term portfolio diversification benefits from exposure to these markets, while the long-term portfolio diversification benefits from exposure to these markets are limited.

## **5. Conclusion**

This study examines the stock market integration among major stock markets of emerging Asia-Pacific economies, viz. India, Malaysia, Hong Kong, Singapore, South Korea, Taiwan, Japan, China and Indonesia. Johansen and Juselius (1990) multivariate cointegration test, Granger causality/Block exogeneity Wald test based on VECM approach and Variance Decomposition Analysis was employed to investigate the dynamic linkages between markets. Cointegration test confirmed a well defined long-run equilibrium relationship among the major stock markets, implying that there exists a common force, such as arbitrage activity, which brings these stock markets together in the long run. These findings are consistent with the results of Jang and Sul (2002) and Choudhry and Lin (2004), who found a significant long-run relationship between the emerging Asian equity markets. The results of Granger causality/Block exogeneity Wald test based on VECM and Variance Decomposition Analysis revealed the stock market interdependencies and dynamic interactions among the

selected emerging Asia-Pacific economies. This result implies that investors can gain feasible benefits from international portfolio diversification in the short-run. On the whole, the study results suggest that although long-term diversification benefits from exposure to these markets might be limited, short-run benefits might exist due to substantial transitory fluctuations.

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